Wirtz Dam Road and Bridge Feasibility Study

December 2005

Submitted to:
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Wirtz Dam Road and Bridge Feasibility Study

submitted to
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Section 1 Introduction

1.1 Purpose and Background

Marble Falls, located northwest of Austin, Texas, in Burnet County is situated outside of the Austin and San Antonio Metropolitan Statistical Areas (see Figure 1). These areas are expanding rapidly toward Marble Falls, bringing jobs and population growth with them. In 2003, Burnet County ranked eleventh in the State in terms of population growth, with a 13.7 percent increase from 2000 to 2003[1]. New developments — such as the Horseshoe Bay Marriott Resort Hotel, which opened in the fall 2004, and the Flatrock Springs Development being planned on a site stretching from FM 2147 to US 71 — are just two examples of the commercial and residential growth taking place within the County. Marble Falls is consistently listed as one of the top non-metropolitan growth areas of the United States[2].

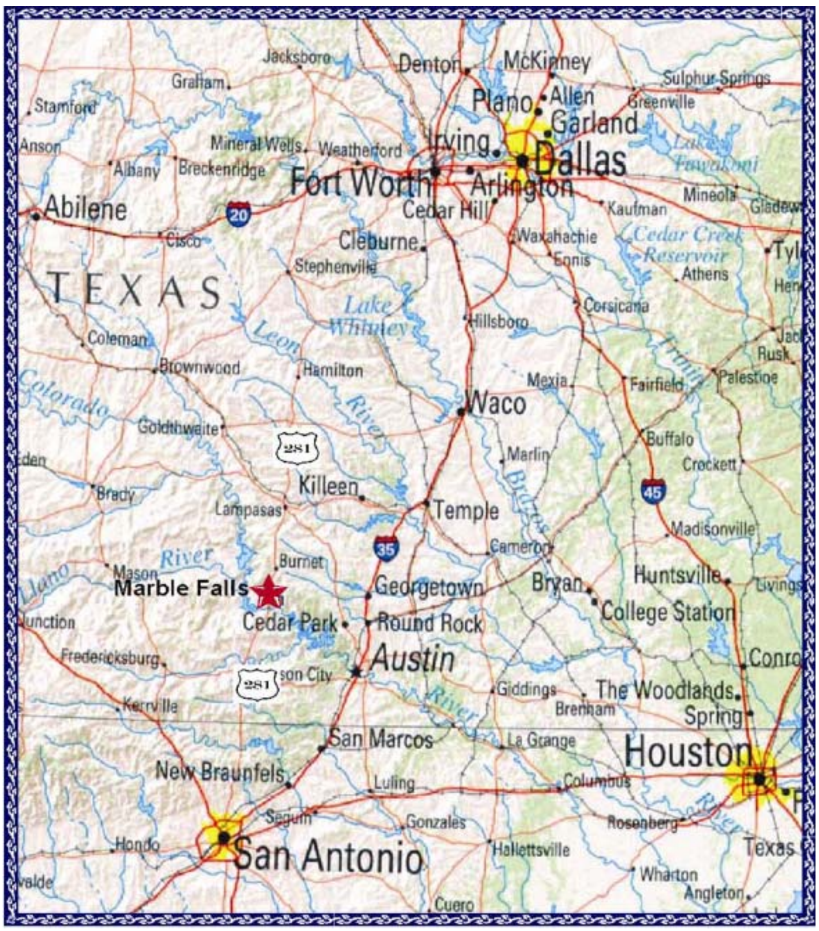

Figure 1: Marble Falls Area Map

One of the main attractions to Marble Falls is its rural nature, with freedom from traffic congestion and a high quality of life. However, the rapid population growth is beginning to result in congestion of the existing roadway network through town and along the roads leading into town, such as FM 2147 and FM 1431. A relief route has been proposed which would provide an alternate north-south connection across the Colorado River west of Marble Falls; however, its cost appears to prohibit construction in the near future.

This study evaluates alternatives for potential impacts of a cost effective crossing of the Colorado River west of Marble Falls just downstream of Wirtz Dam. The new crossing would link FM 2147 with FM 1431, and would alleviate some of the traffic congesting US 281 through Marble Falls. The proposed route would provide the communities of Cottonwood Shores and Horseshoe Bay with a more direct connection to Granite Shoals and Highland Haven, and provide an alternate river crossing should a disaster or accident occur on the US 281 bridge over Lake Marble Falls. It would also provide an alternate route for these communities to travel to the north or south side of Marble Falls without using US 281 at the Colorado River/Lake Marble Falls bridge.

In October 2001, the Lower Colorado River Authority (LCRA) developed a study entitled, "Preliminary Information on Constructing a Bridge Downstream of the Wirtz Dam Area". The preliminary report, developed by the River Operations Engineering Staff, contains information on historic floods, which was useful in the preliminary bridge designs performed for this feasibility study.

1.2 Study Area

Bridge Study Area: The proposed bridge is located over Lake Marble Falls (Colorado River), just downstream of Wirtz Dam. Wirtz Dam is located on Lake Lyndon B. Johnson, west of the City of Marble Falls in Burnet County. The bridge study area includes the northern approach from existing Wirtz Dam Road, the proposed crossing over Lake Marble Falls, and the southern approach from existing Spur 2147.

Other Study Area: Roadways studied, shown in Figure 2, include:

- FM 2147 from US 281 to Spur 2147
- Spur 2147 from FM 2147 to Wirtz Dam Road
- Wirtz Dam Road from Spur 2147 to FM 1431
- FM 1431 from Wirtz Dam Road to the Union Pacific Railroad (UPRR)

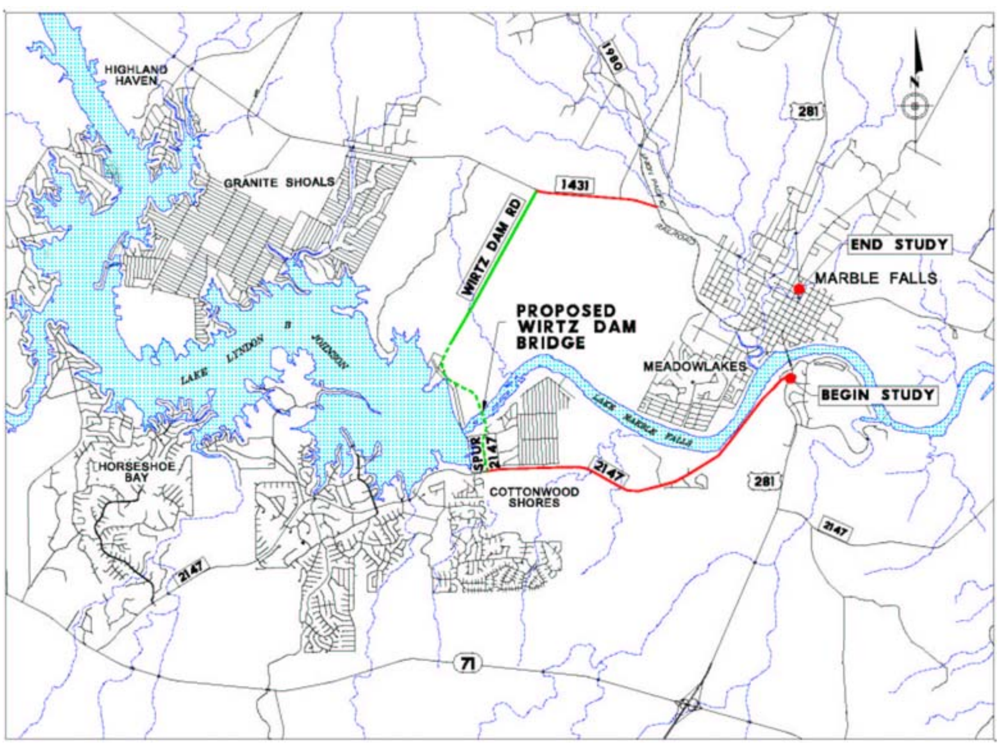

Figure 2: Study Area

Intersections studied include those along the routes given above, plus the US 281/FM 2147 and US 281/FM 1431 intersections.

FM 1431 from UPRR to one mile east will be widened from four to five lanes in 2006 to match the existing five-lane section of FM 1431 that continues eastward to US 281, thus it is not included within this study.

1.3 Existing Development and Community Support

This project will serve the communities of Horseshoe Bay, Cottonwood Shores, Marble Falls, Granite Shoals and Highland Haven. These areas have experienced faster growth than most rural communities over the last decade due to their close proximity to greater Austin and Lakes LBJ & Marble Falls. Planned developments in the area include approximately 30 acres of light manufacturing and office park buildings at Gateway Business Park; La Ventana Mixed Use Development, located at US 281 and RM 2147[3]; and the Flatrock Springs Development, located between FM 2147 and US 71. Major employers include Marble Falls ISD, Wal-Mart, Horseshoe Bay Marriott Resort, HEB Grocery Company, Home Depot, Texas Granite Co., and the City of Marble Falls. These major employers (traffic generators) are shown in Figure 3.[4]

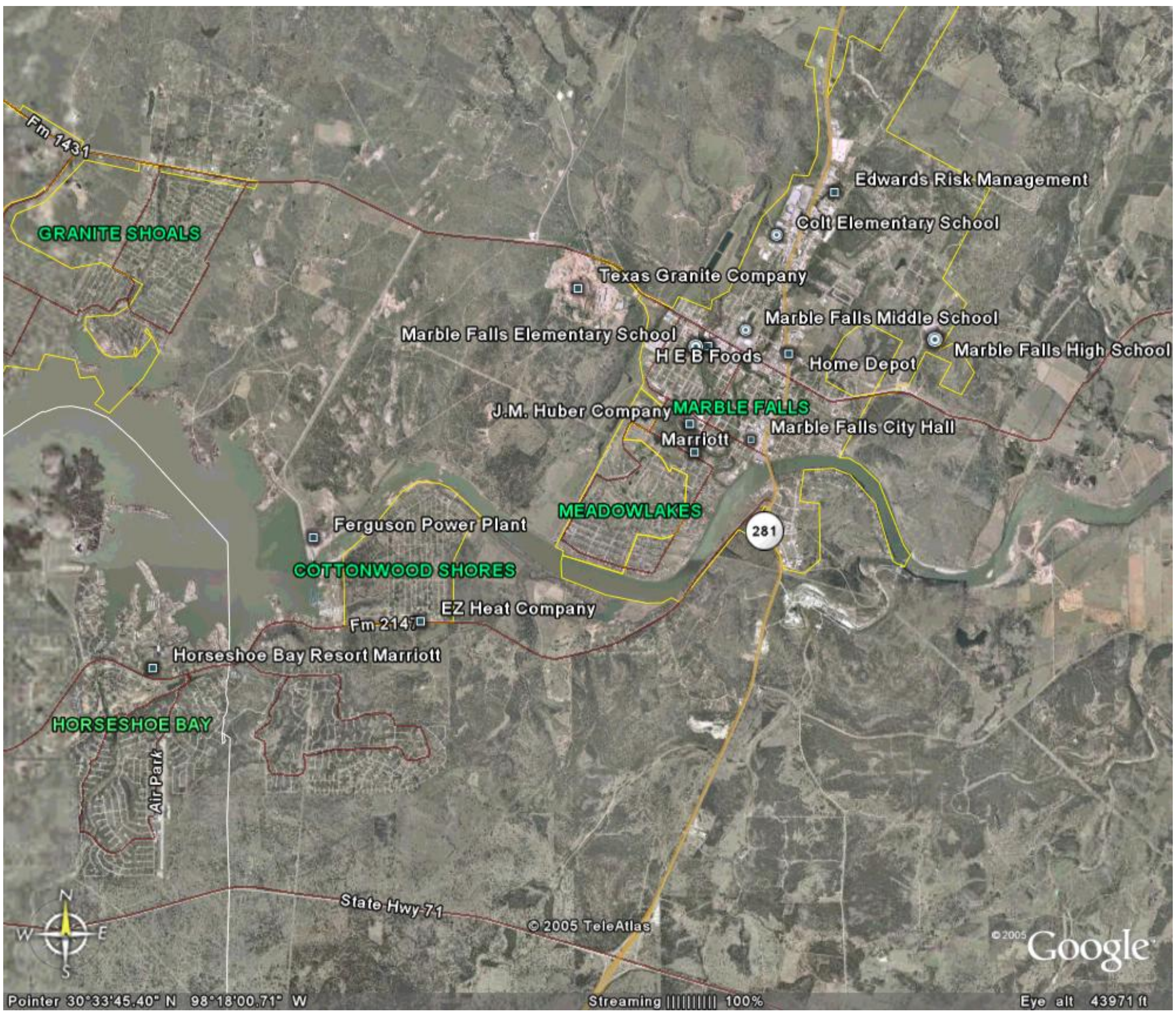

Figure 3: Map of Major Employers in the Area

Emergency medical service (EMS) substations located in Granite Shoals and Horseshoe Bay currently support each other when receiving multiple calls during the same period. When a call for help from across the river is received, the EMS team must travel a long route through the busy corridor previously noted in Marble Falls, which contributes to their response time. However, the availability of an alternate crossing as proposed in this study is predicted to reduce response times between the Granite Shoals/Horseshoe Bay communities by as much as 20 minutes [Johnny Campbell, Director of Marble Falls EMS, in a telephone interview August 25, 2005]. For this reason, the Marble Falls EMS is 100 percent committed to supporting the Wirtz Dam Road and Bridge project.

A public meeting, hosted by Burnet and Llano County Commissioners and the City of Marble Falls, was held July 1, 2004, to present the project and gain public input. The meeting was well attended, with approximately 125 participants. The following stakeholders were present and expressed support for the project [Burnet County Commissioner James Oakley, in a telephone interview, August 12, 2005]:

- Fire and EMS
- Marble Falls Independent School District
- Property Owners Association
- Horseshoe Bay Marriott Resort
- City of Marble Falls
- City of Cottonwood
- Burnet County
- Llano County
- Horseshoe Bay Municipal Utilities District
- Senator Troy Fraser

1.4 Study Scope and Objective

This feasibility study was set to analyze, determine, and/or evaluate the following:

- Wirtz Dam Bridge Analysis
  - ✓ Perform a structural evaluation to determine the requirements of bridge options
  - ✓ Perform a hydraulic capacity determination for multiple flow rates
  - ✓ Develop preliminary geometrics (typical sections, profiles, alignments, spans)
- Wirtz Dam Road Analysis
  - ✓ Develop preliminary horizontal and vertical alignments
  - ✓ Determine required utility adjustments
  - ✓ Determine approximate ROW requirements
- Other Roadways
  - ✓ Determine needed improvements on FM 2147, Spur 2147, and FM 1431 within the roadway limits listed in section 1.2
  - ✓ Determine needed ROW for those improvements identified above
- Traffic Analysis
  - ✓ Develop a preliminary traffic study to estimate the level of usage of the proposed Wirtz Dam Road and Bridge project
  - ✓ Investigate the conformity of the project with the state system and with the local master transportation plan
- Environmental Analysis
  - ✓ Perform an environmental investigation to determine the permits needed and the environmental constraints that exist within the study area
- Cost Estimate
  - ✓ Develop a construction cost estimate for each component of the project

The objective of this study is to provide an informative report containing an engineering analysis and a cost estimate that will enable others to determine if and when the project can be funded, designed, and constructed.

Section 2 Traffic Analysis

2.1 Traffic Volumes

Twenty-four-hour volume data was collected at four different locations, as shown in Figure 4 and identified below. The counts were performed over a total of four days from Saturday, August 20, 2005 through Tuesday, August 23, 2005. Table 1 shows the results of the data collection in vehicles per day. The data collected is included in the appendix of this report.

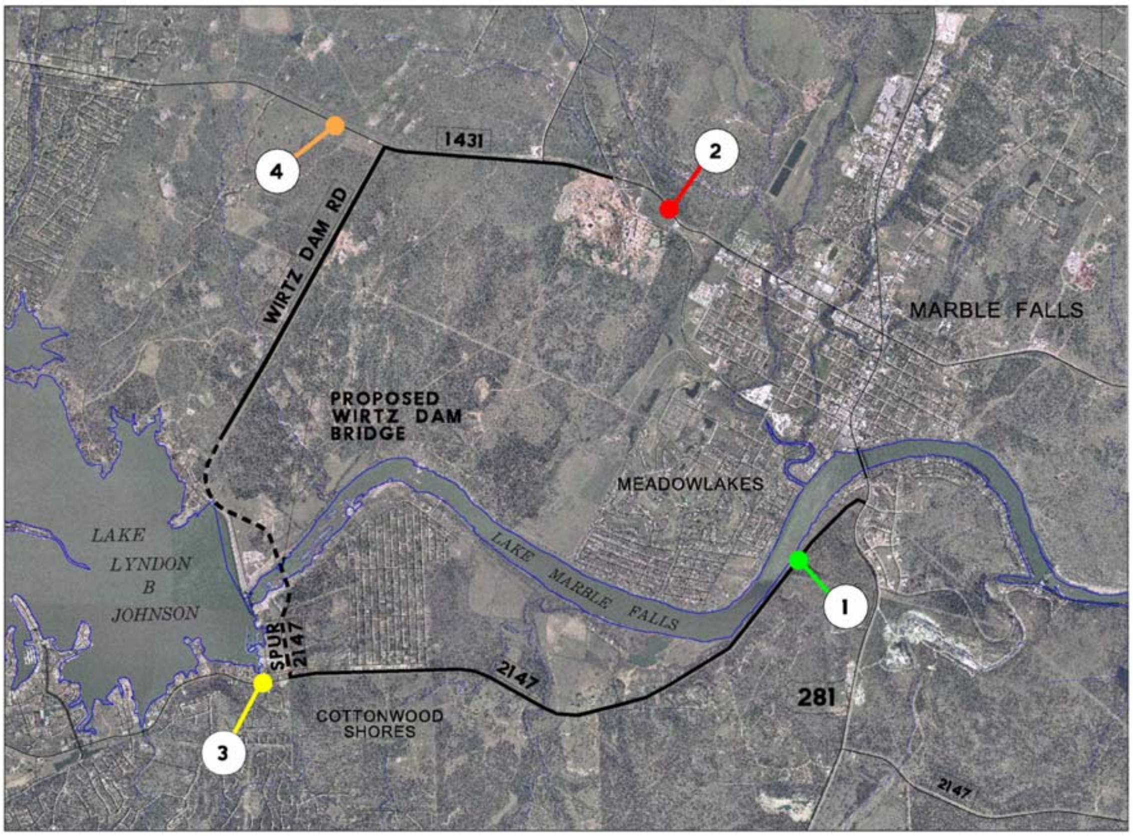

Figure 4: 24 Hour Traffic Count Locations EB/WB

Table 1: 2005 Traffic Volumes

Date	FM 2147 West of Spur 2147	FM 2147 West of US 281	FM 1431 East of the UPRR	FM 1431 West of Wirtz Dam Rd
Saturday, August 20, 2005	7,149	8,889	14,446	16,820
Sunday, August 21, 2005	5,286	6,749	11,571	13,409
Monday, August 22, 2005	7,719	9,527	14,464	17,203
Tuesday, August 23, 2005	8,172	10,091	15,309	18,173

2.2 Traffic Volume Growth

Table 2 below shows the average daily traffic (ADT) from 1992 through 2005. The data from the Texas Transportation Institute (TTI) was obtained from a study entitled *Traffic Growth on Off-System Roadways in Blanco, Burnet, Gillespie, Llano, and Mason Counties*[5]. The traffic volumes were obtained from the TxDOT District Highway Traffic Maps[6]. The traffic volumes obtained by TCB were performed on August 23, 2005. Minor variations in the data could be a result of the time of year, as well as the method and location of the data collection devices.

Table 2: Traffic Volumes

Year	FM 2147 vehicles per day	FM 1431 vehicles per day	Data Source
1992	5,400	10,300	TTI
1997	8,210	15,500	TTI
2000	8,900	18,700	TxDOT
2002	9,890	18,030	TTI
2005	10,091	18,173	TCB

The data shown in Table 2 reflects an annual traffic growth along FM 2147 of 4.93 percent, and an annual traffic growth along FM 1431 of 4.46 percent from 1992 through 2005. It is anticipated that traffic volumes in Marble Falls and the vicinity will continue to grow for the next several years.

Another study by TTI projects a significant growth in traffic volumes between 2000 and the year 2020.

- Between 2000 and 2020, the volume along FM 1431 will increase from 18,000 vehicles per day to 27,840 vehicles per day, which equates to a growth rate of 3 percent per year.
- Between 2000 and 2020, the volume along FM 2147 will increase from 8,900 vehicles per day to 16,850 vehicles per day, which equates to a growth rate of 3.25 percent per year.

According to the TTI study, the current and future operations along US 281, FM 1431, and FM 2147 in the vicinity of Marble Falls operate at an undesirable flow, which is equivalent to a level of service (LOS) of E or worse.[7] LOS is defined as a qualitative measure which describes the operational conditions along a roadway, based on measures such as speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience.

- LOS A – Great conditions along the roadway. The operation of vehicles is virtually unaffected by the presence of other vehicles.
- LOS B – Very good operational conditions along the roadway. Minor disruptions are easily absorbed, although a short local deterioration in LOS will be more obvious.
- LOS C – The operational conditions are still good; however, the volume of traffic is beginning to affect maneuverability.
- LOS D – The operational conditions are beginning to deteriorate. Overall travel speed is beginning to become affected by the volume of traffic.
- LOS E – The roadway is nearing capacity. Vehicles operate with minimum spacing, yet maintain uniform flow. Overall travel speed is affected by the volume of traffic.
- LOS F – The roadway has exceeded capacity. Operations are unstable, with motorists experiencing brief periods of movement followed by stoppages.[8]

2.3 Origin and Destination Study

An origin and destination study was performed along FM 2147 and FM 1431 to help gain an understanding of the amount of traffic that is currently driving through Marble Falls using both FM 2147 and FM 1431. The data collection was performed by GRAM Traffic Counting Inc. on December 12, 2004, from early dawn to dusk, which equates to approximately 12 hours.

To make the determination of the traffic using both FM 2147 and FM 1431, a license plate survey was performed. Cameras were set up in the following locations:

- One camera for westbound FM 2147
- One camera for eastbound FM 2147
- Two cameras for westbound FM 1431 (one camera for the left lane, and one camera for the right lane)
- Two cameras for eastbound FM 1431 (one camera for the left lane and one camera for the right lane)

The purpose of a license plate survey is to record the license plate number of each vehicle as it passes. This can be considered the origin or the destination, depending on the study area and on where the data is collected. This data is then compared to the license plates recorded at a second location. For example, in Marble Falls, the license plates were recorded along FM 2147 going eastbound toward US 281 and Marble Falls. This data was then compared to the license plates recorded along FM 1431 going westbound. If a match in license plates is found within a reasonable span of time, then it can be concluded that the vehicle proceeded from an origin of FM 2147 to a destination along FM 1431.

The biggest problem encountered in a license plate survey is that not all of the license plates can be read due to obstructions, poor lighting, and dirty license plates. This can relate to a small error in the number of plates observed. In the data collection performed along FM 2147 and FM 1431, it was observed that approximately 13 percent of the plates were unreadable. The thirteen percent of plates that were deemed unreadable were distributed based on the calculated percent of readable plates which were determined to have origins or destinations along FM 1431 and FM 2147 respectively. For the purpose of this study, unreadable is defined as less than three successive letters or numbers visible on the license plate.

Since the license plate survey was only performed over approximately 12 hours, a percentage of vehicular traffic utilizing both FM 1431 and FM 2147 was determined. Applying the calculated percentage of vehicles from the license plate survey to the volumes obtained in August 2005, an approximate volume of traffic with origins and destinations along FM 1431 and FM 2147 was determined. Below is a summary of the results of the origin and destination study:

- Ten percent of the traffic along FM 2147 has a destination along FM 1431. This equates to approximately 1,000 vehicles per day that begin along FM 2147 and proceed through Marble Falls toward a destination along FM 1431. This is based on 10,091 vehicles per day from the data collected on August 23, 2005.
- Fourteen percent of the traffic along FM 2147 has an origin along FM 1431. This equates to approximately 2,540 vehicles per day that begin along FM 1431 and proceed through Marble Falls toward a destination along FM 2147. This is based on 18,173 vehicles per day from the data collected in August 2005.
- The total volume with an origin/destination along FM 2147 and FM 1431 is 3,540 vehicles per day.

The data from the license plate survey can be found in the appendix of the report.

2.4 Existing Intersection Traffic Volumes

Existing turning movement counts were performed at the intersections of FM 2147 and US 281, as well as FM 1431 and US 281. The counts were performed on December 15, 2004 between 6 am and 6 pm. The existing turning movement counts can be found in the appendix of this report.

2.5 Intersection Level of Service Analysis

An intersection analysis was performed for the intersections of FM 2147 and US 281, as well as FM 1431 and US 281. The analysis was performed using Synchro 6.0, which calculates the intersection level of service (LOS) and delay based on the methods outlined in the 2000 edition of the *Highway Capacity Manual*. Signal timing information along with existing turning movement counts and existing lane geometry were input into Synchro 6.0 to calculate the LOS and delay.

The analysis was performed using three scenarios.

- Scenario one is the no-build scenario in which traffic volumes were projected from 2004 (when the counts were performed) to the years 2005, 2010, 2015, 2025, and 2030 using the growth rate identified by TTI for FM 2147 of 3.25 percent annually and FM 1431 of 3 percent annually.

- Scenario two is the build scenario. In this scenario, the information from the origin and destination analysis was applied to determine an approximate reduction in traffic at the respective intersections as a result of the construction of the Wirtz Dam Road. For example, a reduction in turning movements at the intersection of FM 2147 and US 281 was assumed based on the origin and destination analysis, which concluded that 14 percent of the existing traffic beginning along FM 1431 continues through Marble Falls and turns right onto FM 2147. Thus, in the build scenario analysis, the southbound right turn movement would benefit from a reduction in traffic. The same is true for the traffic that begins along FM 2147 and continues through Marble Falls to FM 1431. If the Wirtz Dam Road and Bridge is constructed, there would be a 10 percent reduction in the left turning traffic from FM 2147 onto US 281 based on information from the origin and destination study. This analysis was performed using the traffic volumes from 2004, which were then projected forward to the years 2005, 2010, 2015, 2025, and 2030 using the projected growth rates from TTI.

- Scenario three is the no-build scenario with lane re-assignments and signal timings optimized.

The following six tables provide a summary of the intersection analysis and make a comparison between the build and no build scenarios. The improvements to the efficiency of the intersections operations are marginal until the year 2025, when the volumes increase to the point where the intersections are reaching capacity.

Table 3: FM 2147 and US 281 (AM)

Year	No-Build		Build	
	LOS	Delay (sec)	LOS	Delay (sec)
2004	C	25.1	C	23.6
2005	C	25.5	C	23.8
2010	C	27.6	C	26
2015	C	30.7	C	28.5
2020	D	35.6	C	32.5
2025	D	46.0	D	39.7
2030	F	80.1	E	63.3

Table 4: FM 2147 and US 281 (Noon)

Year	No-Build		Build	
	LOS	Delay (sec)	LOS	Delay (sec)
2004	C	27.1	C	25.4
2005	C	27.8	C	26.0
2010	C	30.4	C	28.5
2015	C	34.2	C	31.5
2020	D	40.4	D	36.3
2025	E	64.1	D	52.0
2030	F	109.7	E	92.1

Table 5: FM 2147 and US 281 (PM)

Year	No-Build		Build	
	LOS	Delay (sec)	LOS	Delay (sec)
2004	C	26.6	C	24.7
2005	C	27.0	C	25.2
2010	C	30.9	C	28.4
2015	D	35.3	C	32.7
2020	D	47.4	D	40.1
2025	F	89.6	E	71.0
2030	F	164.2	F	125.7

Table 6: FM 1431 and US 281 (AM)

Year	No-Build		Build	
	LOS	Delay (sec)	LOS	Delay (sec)
2004	C	25.1	C	23.6
2005	C	33.6	C	23.8
2010	C	33.8	C	26
2015	D	35.8	D	28.5
2020	D	36.1	D	35.5
2025	D	38.1	D	38.1
2030	D	45.8	D	45.1

Table 7: FM 1431 and US 281 (Noon)

Year	No-Build		Build	
	LOS	Delay (sec)	LOS	Delay (sec)
2004	C	33.5	C	33.5
2005	C	34.2	C	34.2
2010	D	35.1	D	35.1
2015	D	35.6	D	35.2
2020	D	37.1	D	37.1
2025	D	42.3	D	42.2
2030	E	55.9	E	55.8

Table 8: FM 1431 and US 281 (PM)

Year	No-Build		Build	
	LOS	Delay (sec)	LOS	Delay (sec)
2004	C	34.0	C	34.0
2005	C	34.3	C	34.3
2010	C	34.9	C	34.9
2015	D	35.5	C	35.4
2020	D	38.4	D	38.4
2025	D	47.1	D	47.0
2030	E	79.5	E	79.4

A short-term recommendation for improvement to the intersection of FM 2147 and US 281 is to improve the left turn geometry from a one-lane shared left/through condition to a dedicated left combined with the shared left/through lane. This dual left turn lane option can significantly improve operations at the intersection. For example, in the year 2030, at the intersection of FM 2147 and US 281, the LOS is F with a 162 second delay. By improving the eastbound left turn configuration to a dual left turn, the LOS improves from F with a 125 second delay to a LOS of D with a 39 second delay.

To improve intersection conditions under scenario three, there are some lane re-assignments and new traffic signal timings that could be implemented in the short to long term that would improve operations at both intersections of FM 2147 at US 281 and FM 1431 at US 281. To show how these changes impact the operations, Tables 9 and 10 below outline the LOS and delay for the no-build condition verses the no-build condition with lane re-assignments and new signal timings. The year 2020 was chosen for this analysis since year 2020 is when conditions are projected to deteriorate to a LOS of D for the AM, Noon, and PM peak periods at both intersections analyzed.

Table 9: FM 2147 at US 281 - Year 2020

Period	No-Build		No-Build with Lane Re-assignments & Signal Timing Improvements	
	LOS	Delay (sec)	LOS	Delay (sec)
AM	D	35.6	C	26.2
Noon	D	40.4	C	28.0
PM	D	47.4	C	29.1

Table 10: FM 1431 at US 281 - Year 2020

Period	No-Build		No-Build with Lane Re-assignments & Signal Timing Improvements	
	LOS	Delay (sec)	LOS	Delay (sec)
AM	D	36.1	C	20.2
Noon	D	37.1	C	23.3
PM	D	38.4	C	23.8

Below is a summary of the intersection and signal timing improvements for each intersection analyzed:

FM 2147 and US 281

- Change the lanes at the eastbound approach to the intersection from a shared left/through, exclusive right configuration to an exclusive left, shared left/through/right configuration. This is needed due to the heavy volume of left turning traffic from eastbound FM 2147 onto US 281 northbound.

- With a shared through/left lane condition, the signal timing should be split phased for the eastbound and westbound approaches. This will prevent the condition where a through vehicle is waiting in the shared through/left lane for a green light, thus impeding the predominate left turning vehicular traffic from utilizing the additional left turn lane. Split phasing means that each approach will get a phase of green time which includes left turning, through and right turning traffic, followed by the second phase for the opposing direction left turning, through and right turning traffic. This type of signal phasing is primarily used at high volume intersections that have a heavy turning movement such as FM 2147 and US 281.

- Since this intersection is so busy it is imperative that the signal operate at the most efficient level that is possible for the lane configurations provided. This can be accomplished by operating the signal as a fully actuated intersection. This equates to having vehicular detection for all approaching lanes to the traffic signal. This could be done with a video imaging vehicular detection system (VIVDS) which will include cameras at each intersection approach. VIVDS are a good option since they do not require as much maintenance as the loop detector system which required a physical wire to be placed within a cut in the existing pavement surface.

FM 1431 and US 281

- Change the lanes at the eastbound approach to the intersection from an exclusive left, exclusive through and shared through/right configuration to an exclusive left, shared left/through and shared through/right configuration. This is needed due to the heavy volume of left turning traffic from eastbound FM 1431 onto US 281 northbound.

- With a shared through/left lane condition, the signal timing should be split phased for the eastbound and westbound approaches. This will prevent the condition where a through vehicle is waiting in the shared through/left lane for a green light, thus impeding the predominate left turning vehicular traffic from utilizing the additional left turn lane. This type of signal phasing is primarily used at high volume intersections that have a heavy turning movement such as FM 1431 and US 281.

2.6 Travel Times

Travel time and delay are two important measures of the operations of a highway system. A travel time study provides data on the amount of time it takes to traverse a section of highway. The travel times taken along FM 2147 to FM 1431 and from FM 1431 to FM 2147 included the running time (which is the time the vehicle was in motion) and the stopped time delay (which is the time that the vehicle was stopped). Travel times were taken along two routes for off-peak and peak period conditions.

Route 1: Counterclockwise from Spur 2147 to FM 2147 to US 281 to FM 1431 to Wirtz Dam Road

Off-peak Period
- 11 minute 23 second average running time
- 55 second average stopped time delay
- 48 mph average travel speed

Peak Period
- 11 minute 19 second average running time
- 3 minute 15 second stopped time delay
- 48 mph average travel speed

Route 2: Clockwise from Wirtz Dam Road to FM 1431 to US 281 to FM 2147 to Spur 2147

Off-peak Period
- 11 minute 14 second average running time
- 58 second average stopped time delay
- 48 mph average travel speed

Peak Period
- 11 minute 12 second average running time
- 1 minute 57 second stopped time delay
- 48 mph average travel speed

2.7 Highway Analysis

Based on the traffic volumes from the origin and destination study, a two-lane section will be sufficient to carry the projected traffic along the Wirtz Dam Road and Bridge for a period well into the foreseeable future. Using the Highway Capacity Manual and Highway Capacity Software, the following assumptions were made in the two-lane highway level of service analysis:

- Rolling Terrain
- 10-foot shoulder
- 12-foot lanes
- K factor = 0.1
- Directional Distribution = 60/40
- Peak Hour Factor (PHF) = .92

A growth rate of 3 percent (based on information from TTI) was used to determine the LOS and ADT through the year 2030. Table 11 below shows the summary of the analysis results.

Table 11: Highway LOS Analysis

Year	ADT	LOS
2005	3,540	B
2010	4,300	B
2015	4,900	B
2020	5,700	B
2025	6,600	B
2030	7,700	C

According to Tim Dolan, Marble Falls City Planner, the Wirtz Dam Road and Bridge project could become the western portion of the future loop around Marble Falls. Having the majority of the ROW and an existing Wirtz Dam Roadway for most of the 3.8 miles is worth moving the western portion of the loop a bit further west to the Wirtz Dam Road to save funding over a new location facility. Therefore, the project is in conformity with the community's draft master thoroughfare plan.

Section 3 Wirtz Bridge Analysis

3.1 Description of Design Criteria and Options

Design criteria for the proposed bridge were defined by the TxDOT *Roadway Design Manual*. Design speeds of 40 mph through 60 mph were developed and analyzed. A design speed of 45 mph was chosen for the bridge study area alignment due to horizontal curve restraints of existing Wirtz Dam Road, the power transmission towers, and to stay within as much of the LCRA ROW as possible. This design speed also worked well with topography (thus minimizing major cuts in granite) and with vertical curve constraints. Finally, this design speed also works well with the future use of the road once development occurs along it.

Additional alignments that place the proposed bridge at more of a perpendicular angle to the flow of water are possible. This could result in a bridge length that is reduced by 5 percent to 10 percent. However, these alignments tend to place the Wirtz Dam Road closer to the dam. They also will require more cut and fill, since they will not follow the existing roadway on the north side of the lake. In the preliminary design phase of the project, various alignments should be analyzed in coordination with LCRA (for proximity to the dam) and with TxDOT for bridge construction. The alignment chosen for this feasibility study is the one discussed with TxDOT, LCRA, and public officials in numerous site visits, and the one that uses the existing roadway alignment as much as possible on the north side of Lake Marble Falls.

3.2 Structural Considerations

Bridge Strength: This proposed bridge crossing will need to endure 100-year storms having velocities of up to 12 feet per second that carry debris and occasionally wash granite boulders into the bridge columns. The substructure must also handle a potential scouring problem in the fractured granite. For these reasons and to accommodate a dam breach or overtopping, oversized bridge bents with 30′ deep drill shafts are recommended.

For bridges designed to handle floods less than the 100-year, the bridge will need additional strengthening for the superstructure to withstand flows that wash against it. Due to the velocities encountered just down-stream of a dam, getting the superstructure above the 100-year water surface elevation is very desirable.

Bridge Profiles: Using the horizontal alignment developed for the 45 mph design speed, four bridge crossing design profiles were developed from a hydraulic standpoint (see Appendix for profile layouts). For the three higher profiles, abutments were placed and bent locations identified for two bridge options. The bridge bents were placed to allow as much construction as possible to occur on dry land. The two bridge options are:

- Bridge Option I – uses pre-stressed concrete TxDOT Type IV beams
- Bridge Option II – also uses pre-stressed concrete TxDOT Type IV beams at the ends of the bridge, and uses steel plate girder spans in the mid-portion of the bridge over water.

A third structure type was considered for a low-water bridge that would accommodate normal power generation. Due to frequent overtopping of the bridge, a thin profile cast-in-place slab span structure was thought to be the best solution. This type of structure has the added benefit of stronger superstructure to substructure attachment. The disadvantage to this type of structure is that the spans are limited to about 25 feet.

Bridge Typical Sections: After analyzing the existing and future traffic needs, a typical section of 52′ total width was developed. Figure 5 shows the 52-foot wide typical section using Bridge Option I discussed above (pre-stressed concrete beams). Figure 6 shows the same typical section using Bridge Option II (steel plate girder construction). The rails shown are TxDOT standard rails T401 and C401, which will provide safety and visibility for the traveling public.

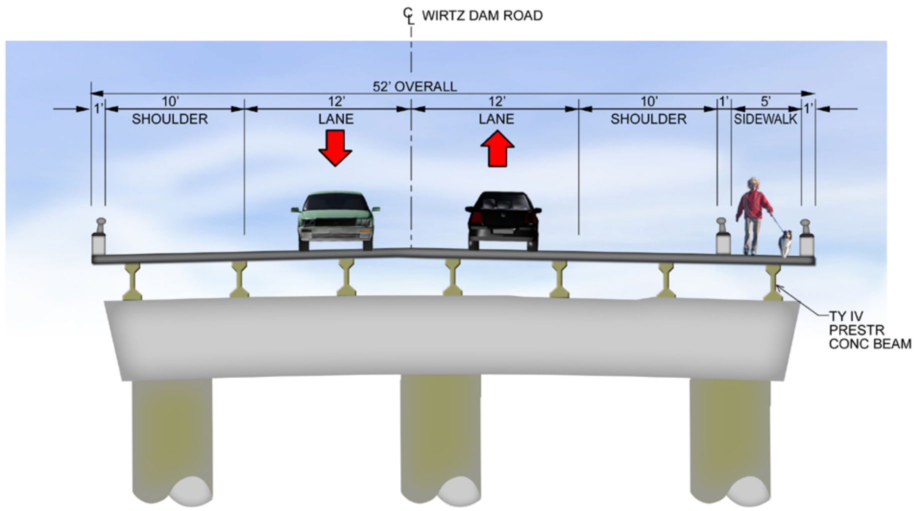

Figure 5: Proposed Wirtz Dam Bridge with Concrete Beams

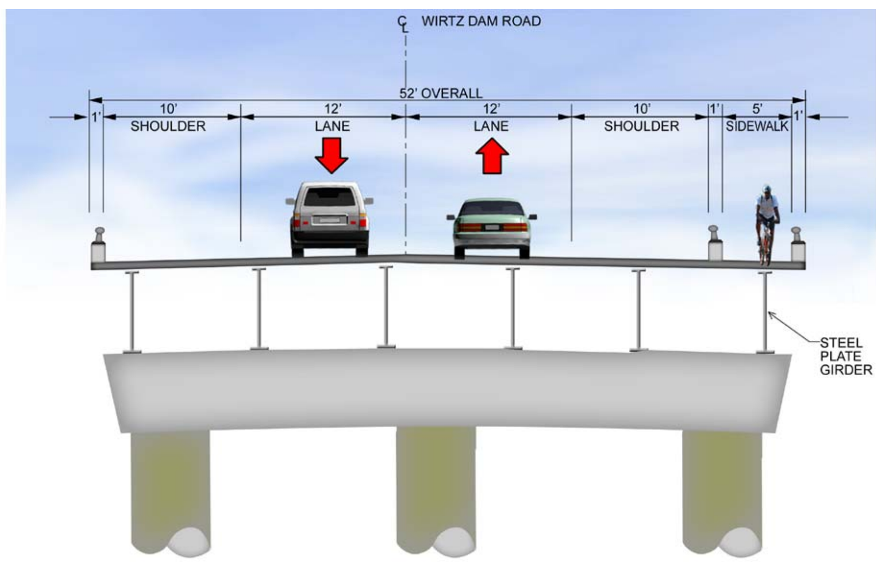

Figure 6: Proposed Wirtz Dam Bridge with Steel Girders

When four lanes are needed, a parallel structure may be constructed on the east side of the proposed 150′ of right of way (ROW) in the bridge area; or if funding is in short supply, the 52-foot wide structure could be re-worked to a configuration of:

1′ rail + 2′ shoulder + 11′ lane + 12′ lane + 12′ lane + 11′ lane + 2′ shoulder + 1′ rail

If a re-work is chosen, a separate pedestrian/bicycle bridge could be constructed.

The Type IV beams shown in the typical bridge section can span 120′, which provides an economical span arrangement. Additional benefits are the relative ease of transport to the site, quick construction, and that contractors are familiar with the standard Type IV beam and should bid it competitively. In Texas, this type of structure traditionally provides the lowest cost solution for bridges of similar size and location.

The three steel girder spans designed for this location span 240′ each and can be designed as a three-span unit. They are spaced across the typical bridge section. This site is an ideal location for weathering steel, which is left unpainted and requires no long-term maintenance. The Type IV beams are used at each end of the steel unit and complete the bridge length. The longer steel spans allow for three less bents, but are likely to be more costly. With the difficulty of constructing the large drilled shafts in granite, and fluctuating steel prices, this alternative cannot be arbitrarily ruled out. Further cost evaluation during the design phase is recommended.

The bridge aesthetics can be improved using rustication on the bridge columns, earwalls on the bents, color, and perhaps single column bents with enhancements, such as heavy chamfers and the use of form liners. Note that, due to their relative ease and speed of construction, three-column bents were selected as the basis for this report.

Bridge Lengths: The bridge lengths for the four profiles for Bridge Options I and II are shown in the next two tables and on the bridge profiles included in the appendix.

Table 12: Option I Bridge Lengths

Bridge Option I: Type IV Prestressed Concrete Beams			
Storm Event Frequency (years)	**Ty IV Spans**	**Typ. Span Length (ft)**	**Bridge Length (ft)**
2 Turbines operating	N/A	25	980
10	9	120	1,050
25	10	120	1,178
100	11	120	1,320

Table 13: Option II Bridge Lengths

Bridge Option II: Type IV Prestressed Concrete Beams at Bridge Ends with Interior Steel Girder Spans					
Storm Event Frequency (years)	**Ty IV Spans**	**Typ. Span Length (ft)**	**Steel Spans**	**Span Length (ft)**	**Bridge Length (ft)**
2 Turbines operating	N/A	25	N/A	N/A	980
10	3	120	3	240	1,050
25	4	120	3	240	1,178
100	4	120	3	240	1,320

Bridge Costs: The bridge and approach roadway preliminary cost estimates are shown in the appendix and are summarized in Table14 below:

Table 14: Preliminary Bridge and Approach Roadway Construction Cost Estimates

Storm Event Frequency (years)	Option I ($Mil.)	Option II ($Mil.)
2 Turbines operating	6.42	N/A
10	6.55	8.11
25	7.00	8.41
100	7.50	8.88

3.3 Hydraulic Considerations

Over the years, the LCRA has carefully developed hydrologic and hydraulic models of the lower Colorado River and its lakes. Those models were made available for this study. TCB included the proposed bridge structure that would generate the most backwater (Option 1) into LCRA's HEC-RAS hydraulic model for the design frequency storm events shown in the table below. This allowed a determination of what hydraulic effect each bridge structure will have on the water surface elevation. The HEC-RAS run showed that the bridge will only raise the water surface elevation upstream at the dam by up to 0.29′ during power generation times (when two turbines are operating). According to LCRA, power generation could proceed with negligible efficiency loss as long as the backwater effect from the proposed structure did not raise the water surface elevation by more than 1.00′.

The following four tables show hydraulic data for five flowrates for each of the four profile bridge designs. The 0.29′ headwater rise encountered for the Low Water Crossing Bridge design is the highest of the four bridge designs for a flowrate of 9,400 cfs (when two turbines are operating). Therefore, the backwater effect does not appear to be a problem with regard to power generation.

Table 15: HEC-RAS Hydraulic Model Data for the Low Water Crossing Bridge

Storm Event Frequency (years)	Flowrate (CFS)	Water Surface Elev. @ Dam (without a bridge)	Water Surface Elev. @ Dam (with a bridge)	Headwater Rise (Feet)	Velocity (Ft./Sec.) (with a bridge)
1 Turbine operating	4,700	740.31	740.58	0.27	1.42
2 Turbines operating	9,400	742.20	742.49	0.29	2.06
10	162,322	763.22	764.30	1.08	8.30
25	250,369	770.10	770.70	0.60	9.93
100	367,210	777.82	778.37	0.55	11.78

Table 16: HEC-RAS Hydraulic Model Data for the 10-Year Bridge (Option I – 9 Spans)

Storm Event Frequency (years)	Flowrate (CFS)	Water Surface Elev. @ Dam (without a bridge)	Water Surface Elev. @ Dam (with a bridge)	Headwater Rise (Feet)	Velocity (Ft./Sec.) (with a bridge)
1 Turbine operating	4,700	740.31	740.54	0.23	1.42
2 Turbines operating	9,400	742.20	742.41	0.21	2.06
10	162,322	763.22	763.62	0.40	8.30
25	250,369	770.10	770.61	0.51	9.93
100	367,210	777.82	779.38	1.56	11.78

Table 17: HEC-RAS Hydraulic Model Data for the 25-Year Bridge (Option I – 10 Spans)

Storm Event Frequency (years)	Flowrate (CFS)	Water Surface Elev. @ Dam (without a bridge)	Water Surface Elev. @ Dam (with a bridge)	Headwater Rise (Feet)	Velocity (Ft./Sec.) (with a bridge)
1 Turbine operating	4,700	740.31	740.54	0.23	1.42
2 Turbines operating	9,400	742.20	742.41	0.21	2.06
10	162,322	763.22	763.56	0.34	8.30
25	250,369	770.10	770.53	0.43	9.93
100	367,210	777.82	778.26	0.44	11.78

Table 18: HEC-RAS Hydraulic Model Data for the 100-Year Bridge (Option I – 11 Spans)

Storm Event Frequency (years)	Flowrate (CFS)	Water Surface Elev. @ Dam (without a bridge)	Water Surface Elev. @ Dam (with a bridge)	Headwater Rise (Feet)	Velocity (Ft./Sec.) (with a bridge)
1 Turbine operating	4,700	740.31	740.54	0.23	1.42
2 Turbines operating	9,400	742.20	742.41	0.21	2.06
10	162,322	763.22	763.57	0.35	8.30
25	250,369	770.10	770.54	0.44	9.93
100	367,210	777.82	778.41	0.59	11.78

There is one creek crossing on Wirtz Dam Road, shown in Figure 7. Preliminary hydrologic and hydraulic analyses were performed on Deep Creek. A county road in a developing area should be designed for the 25-year storm event. A preliminary hydraulic analysis indicated that three 9′ wide by 6′ high multiple box culverts are needed at this location to convey the 25-year storm event of 1,583 cubic feet/second. The drainage area contributing to this flow is 1.48 acres, as shown in Figure 8. Deep Creek is defined as a Zone A Flood Hazard Area. The final design of the culverts will need to minimize adverse impacts to the base flood elevation and to comply with the National Flood Insurance Program. Please note that the proposed Wirtz Bridge will accommodate the 100-yr storm event for several reasons (see page 14).

Figure 7: Deep Creek at its Crossing of Wirtz Dam Road

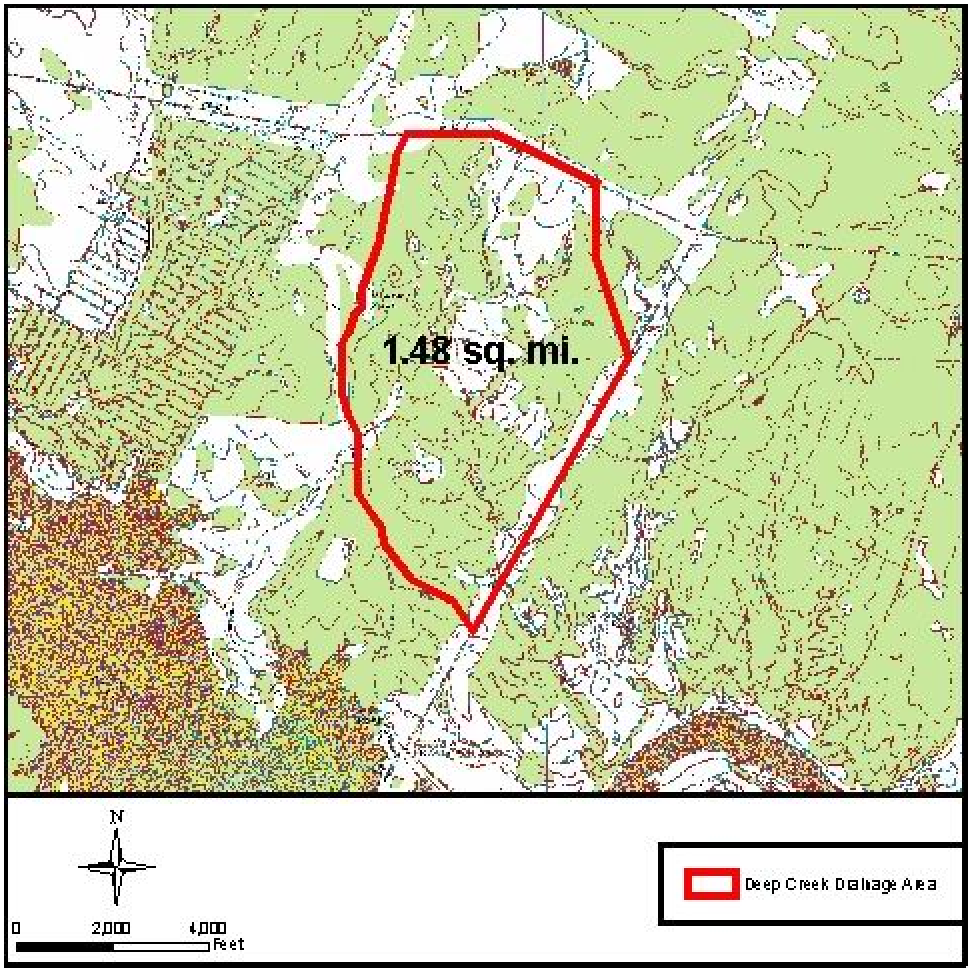

Figure 8: Deep Creek Drainage Area

3.4 Environmental Considerations

3.4.1 Land Use

Bridge Study Area: The majority of land adjacent to the river is open space owned by the LCRA, and is related to the operation of Wirtz Dam. Constructed from 1949 to 1950, Wirtz Dam was built to provide hydroelectric power. The dam was built in conjunction with the construction of the Starcke Dam, located downstream. Wirtz Dam, owned by LCRA, creates Lake LBJ. Lake LBJ provides cooling water for LCRA's Thomas C. Ferguson Power Plant along Horseshoe Bay. Sunset Point on Lake LBJ is an RV park and campground located adjacent to the north end of Wirtz Dam. It is operated by a private owner, and is located on land that is leased from LCRA and adjoining privately-owned land. Granite Beach recreation area is a boat ramp and recreation area adjacent to the south end of Wirtz Dam. It includes a boat club and marina, cabins, restaurant, water park, and sail and ski rentals. LCRA leases the property to private operators.

Additional Study Area: The areas adjacent to Wirtz Dam Road, and the section of FM 1431 included in the study, are primarily undeveloped land. A portion of FM 2147 directly west of US 281 is located adjacent to Lake Marble Falls, and the topography falls steeply away from the road toward the shore and rises from the road with a steep grade cut into the existing rock. The remaining area along FM 2147 is largely undeveloped land to the north and south of the roadway. There are a few residential properties and commercial properties located along FM 2147. Signage for property sales and development exist in many areas along FM 2147. The community of Cottonwood Shores (population 548) lies to the east of Spur 2147 along FM 2147. It includes commercial development along the north side of FM 2147, and residential property between the commercial development and Lake Marble Falls.

3.4.2 Vegetation

Bridge Study Area: Vegetation includes those species associated with native grass prairie and post oak-live oak savannah. Grasses include little bluestem, indiangrass, big bluestem, and sideoats grama. Tree species include live oak, post oak, mesquite, and juniper. Woody shrubs include juniper, Texas persimmon, and mesquite.

Additional Study Area: Vegetation along the roads within the additional study area includes mixed grasses and scattered trees, with larger trees and denser vegetation concentrated along drainages. Dominant grasses are little bluestem, indiangrass, hairy grama, buffalograss, johnsongrass, and sandhill lovegrass. Trees species include live oak, post oak, cedar, elm, mesquite, and juniper. Additional species include Indian blanket, coreopsis, mustang grape, yucca, and prickly pear cactus.

3.4.3 Threatened and Endangered Species

Bridge Study Area: A search of the Natural Diversity Database at the Texas Parks and Wildlife Department (TPWD) Wildlife Diversity Center did not indicate recorded Federal or State listed species or species of concern in the bridge study area.

Additional Study Area: A search of the Natural Diversity Database at the TPWD Wildlife Diversity Center indicated that no known Federal or State listed species are recorded in the study area (see Table 1919 below). The database search did find one recorded occurrence of one plant species of concern, Edwards Plateau cornsalad (*Valerianella texana*), along FM 2147. The species is not State listed as endangered or threatened in Burnet County. No other species of concern are directly adjacent to the study area. Occurrences of the Black-capped Vireo (*Vireo atricapillus*) were listed in Burnet County and reported within three miles of the study area northwest of Marble Falls, but not in the immediate vicinity of the project.

Table 19: Federal and State Listed Threatened/Endangered Species in Burnet County

Species	USFWS*	TPWD**	Known Occurrence in Project Area
Bone Cave Harvestman	LE	-	No
American Peregrine Falcon	DL	E	No
Arctic Peregrine Falcon	DL	T	No
Bald Eagle	LT-PDL	T	No
Black-capped Vireo	LE	E	No
Golden-cheeked Warbler	LE	E	No
Interior Least Tern	LE	E	No
Whooping Crane	LE	E	No
Black Bear	T/SA-NL	T	No
Gray Wolf	LE	E	No
Red Wolf	LE	E	No
Texas Horned Lizard	-	T	No

* U. S. Fish and Wildlife Service (E = endangered, T = threatened, C = candidate, LE or LT = federally listed endangered/threatened, E/SA or T/SA = threatened by similarity of appearance, DL = delisted, PDL = proposed delisting)
** Texas Parks and Wildlife Department (E = endangered and T = threatened)

3.4.4 Cultural Resources

Bridge Study Area: A record search at the Texas Archaeological Research Laboratory (TARL) identified two known archaeological features in the vicinity. The sites are determined to be of prehistoric origins. One site is determined to have no research potential. The other site is so extensively looted, that its only research value lies in the location of its existence.

Additional Study Area: A TARL search of the additional study area revealed two cultural resource sites along existing FM 2147. One site is determined to be somewhat impacted from the existing roadway. No additional right-of-way is anticipated in this study; therefore, no additional investigation would be required. Additional sites were also identified beyond the immediate area of the existing roadways. A resource site is documented in the area of Wirtz Dam Road, but the research value has been determined as low, with some disturbance. Due to a record of cultural resources in the area, any proposed project outside of the existing right-of-way should include further investigation.

3.4.5 Public Lands

Bridge Study Area: The study area for the bridge and approaches is primarily on land owned by LCRA. There is a privately owned recreation area on the north side of Wirtz Dam at the intersection of Wirtz Dam Road and Spur 2147. The facility, Sunset Point on Lake Lyndon B. Johnson, is an RV park and campgrounds. The LBJ Yacht Club and Marina at Granite Beach, located on the south side of Wirtz Dam, is a partnership park with the LCRA. The facility includes recreational opportunities and public amenities, including a restaurant and boat rentals.

Additional Study Area: There were no public or recreational lands identified adjacent to or in the immediate vicinity of the proposed road improvements.

3.4.6 Waters of the United States

Bridge Study Area: The Colorado River, up to the limits of the Ordinary High Water Mark (OHWM), is considered waters of the U.S., and would require a Section 404 permit (Clean Water Act) for the placement of dredged or fill material into any jurisdictional areas, including adjacent wetlands.

If impacts to waters of the U.S. are expected to be less than one-half of an acre of water, the impacts can be authorized under Section 404 of the Clean Water Act by Nationwide Permit 14 for linear transportation projects. A pre-construction notification would be required if the impacts are greater than one-tenth of an acre, or if jurisdictional wetlands would be expected to be impacted by the proposed project.

Additional Study Area: The study area for the road improvements includes several crossings of intermittent streams that are potentially waters of the U.S. Within the project limits, FM 2147 crosses three potential waters of the U.S.: Tiger Creek, Varnhayen Creek, and a tributary to Varnhayen Creek. Along Wirtz Dam Road, there are four potential waters of the U.S.: Deep Creek, a tributary to Deep Creek, and two crossings of an unnamed drainage to the Colorado River. FM 1431 crosses one potential waters of the U.S, a tributary to Williams Creek. Minor amounts of wetland vegetation were present at these crossings, but delineation was not performed. Impacts at these crossings would most likely be less than one-tenth of an acre, and would be able to be authorized by Section 404 Nationwide Permit 14.

3.4.7 Navigable Waters/Section 10/Coast Guard Bridge Permit

According to the U.S. Army Corps of Engineers (USACE), the limits of navigability on the Colorado River extend from the Bastrop-Fayette County line upstream to Longhorn Dam in Travis County just downstream of Austin. This location is at a substantial distance downstream of the project area; therefore, there would be no requirements for a Section 10 Permit (Rivers and Harbors Act of 1899). Although the need for a

Coast Guard Bridge permit is unlikely, due to the many dams on the upper Colorado River and the limited navigability at this location, a determination for a Coast Guard Bridge permit is recommended.

3.4.8 Environmental Summary

A preliminary environmental evaluation of a proposed new bridge over Lake Marble Falls (Colorado River), including associated roadway improvements, indicated that the construction of the bridge may require a USACE Section 404 Permit. However, it is likely the acquisition of the permit would not require coordination with USACE, and could be authorized by Section 404 Nationwide Permit 14. The smaller crossings at creeks and drainages along the proposed roadway improvements could be authorized under a similar manner. A USACE Section 10 Permit would not be needed. However, coordination with the Federal Highway Administration would be needed to determine the need for a Coast Guard Bridge permit. A search of known archaeological sites in the project area identified two archaeological sites in the area of the proposed bridge crossing. These sites have both been disturbed, but would still require coordination with the Texas Historical Commission if they were to be impacted by the construction of the project. A search of known endangered species occurrences in the study area indicated that none are likely to be affected by the project. Further investigation of these and other environmental issues would need to be performed as project planning progresses. Compliance with the National Environmental Policy Act would likely require the preparation of a moderate-level Environmental Assessment (Finding of No Significant Impact) and public involvement prior to approval of Federal funds for the project.

3.5 Security Considerations

Domestic infrastructure security became a real concern after the terrorist attacks of September 2001; consequently, the section of Wirtz Dam Road running closest to the dam (on LCRA property) was closed to through traffic shortly thereafter. A chain link fence surrounds the LCRA property and gates block access to the section of Wirtz Dam Road running closest to the dam.

To prevent access to the dam, an 8-foot chain link fence with razor wire is recommended on either side of the roadway ROW throughout the LCRA property. This chain link fencing would need to connect to the bridge ends. The bridge can simply have a typical rail since it will be high above the shallow water.

Section 4 Roadway Analysis

4.1 Description of Existing Conditions and Recommendations

4.1.1 FM 2147: Spur 2147 to US 281

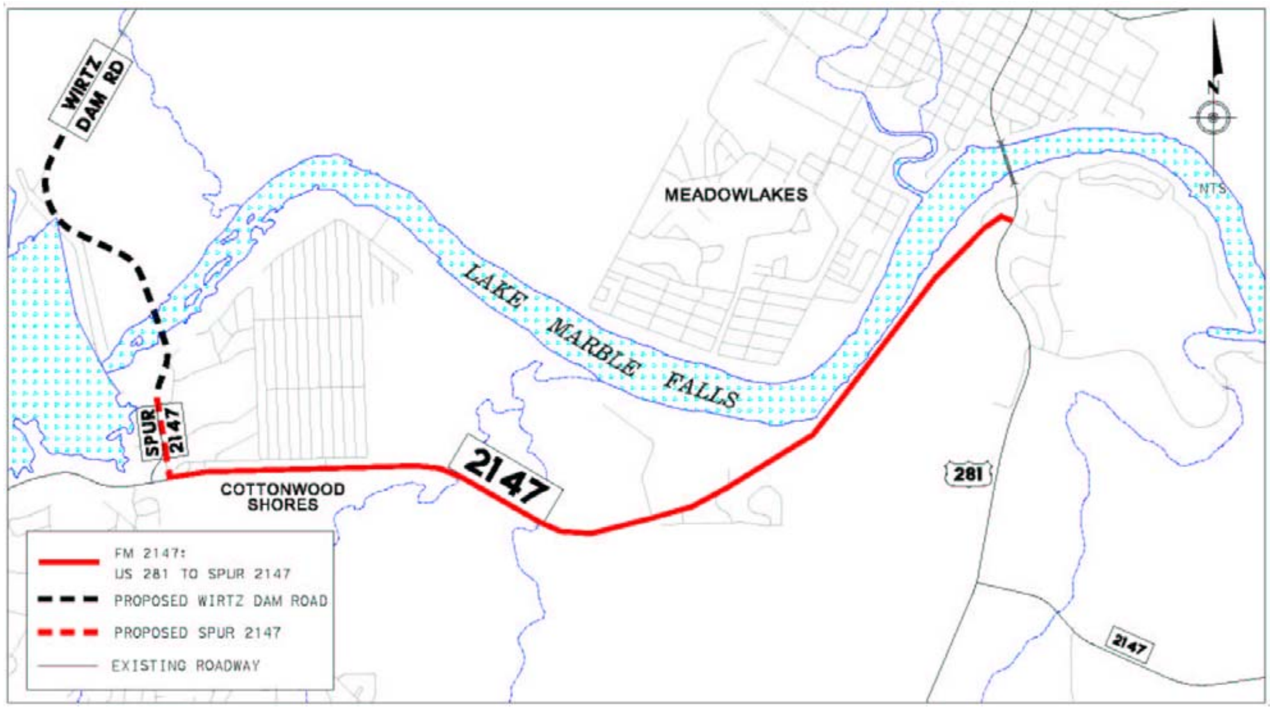

Figure 9: FM 2147 from US 281 to Spur 2147

As depicted in Figure 9, FM 2147 runs from US 281 to the west for 4.16 miles to its intersection with Spur 2147. For the eastern 1.5 miles, FM 2147 is near Lake Marble Falls, and has a significant drop-off to the north. It also has a steep cliff rising from the south side of the roadway. There are existing power poles in this segment of FM 2147. The roadway is primarily undeveloped, with some residential and commercial use becoming more frequent near the community of Cottonwood Shores at the intersection of Spur 2147.

FM 2147 from US 281 to Spur 2147 is a two-lane rural undivided highway (see Figure 10 and Figure 11). The road contains a yellow double stripe down the center and white shoulder stripes. Construction plans were used to evaluate cross-section, and horizontal and vertical geometry for this roadway. The construction plans show two 10-foot lanes with 4-foot shoulders; however, as shown in Figure 10, it appears the roadway has been overlaid and re-striped to 12-foot lanes with 2-foot shoulders.

Figure 10: FM 2147 Looking West

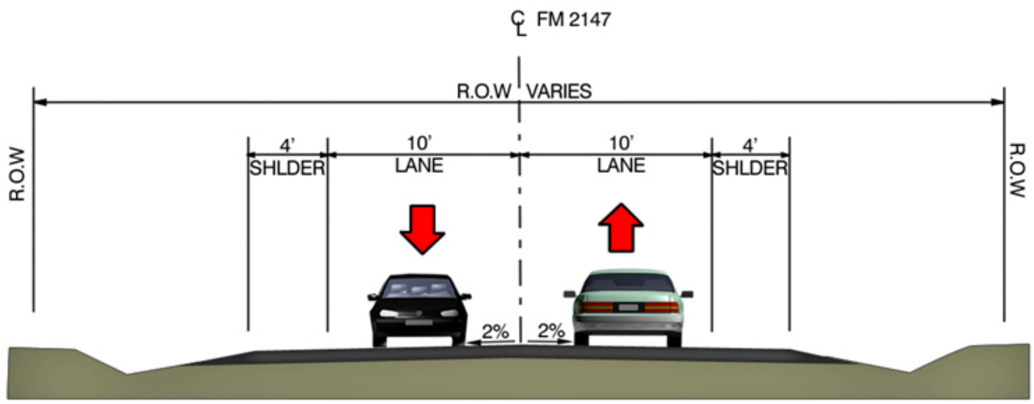

Figure 11: Existing FM 2147 Typical Section

A section of FM 2147 from Slick Rock Creek to Castlerock is currently listed on TxDOT's Fiscal Year 2006 Transportation Improvement Program (TIP). The roadway will be upgraded to two 12-foot lanes with a 14-foot two-way left turn lane (TWLTL) and 12-foot shoulders.[9] The same typical section is recommended for FM 2147 from Spur 2147 US 281. At FM 2147 and US 281, a dual left turn option (a left turn lane and an optional left/through lane) is recommended for the eastbound to northbound movement.

4.1.2 Spur 2147 and Wirtz Dam Road

As depicted in Figure 12, Spur 2147 extends approximately 956 feet north of the intersection of FM 2147. This segment contains two sharp horizontal curves that do not meet current 45 mph design criteria. It is recommended that Spur 2147 be straightened to eliminate the sharp reverse curves.

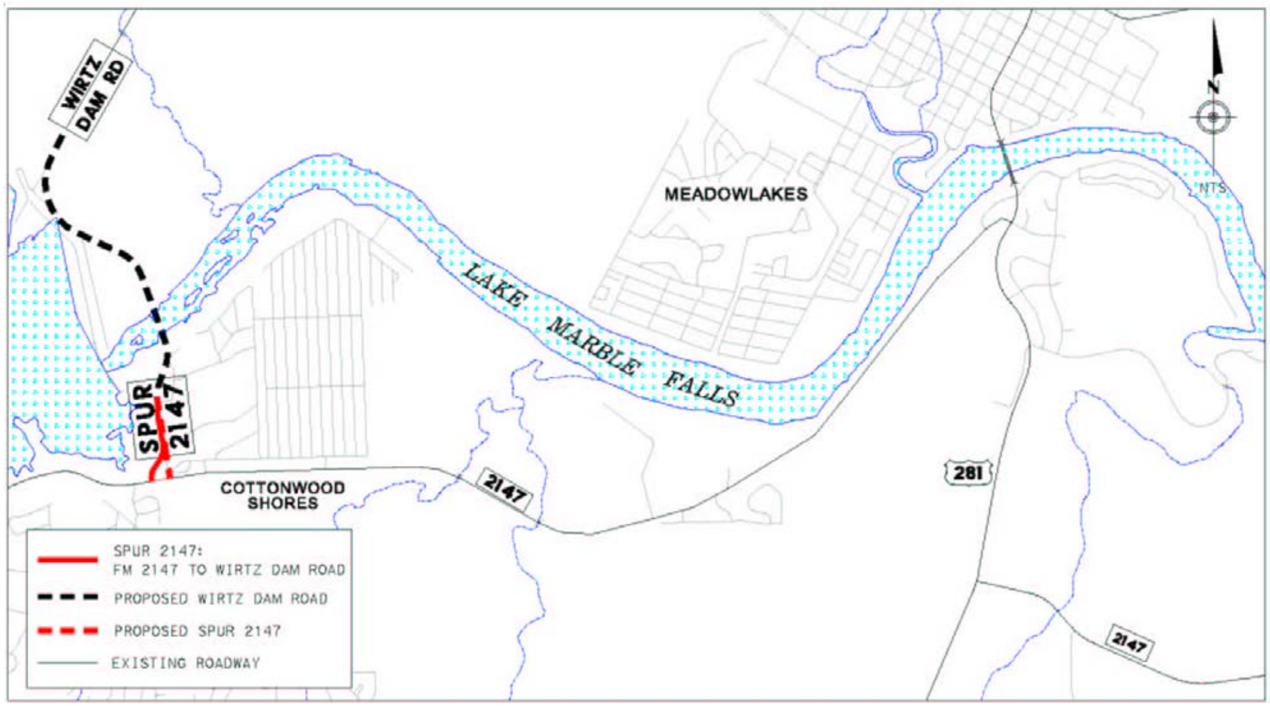

Figure 12: Spur 2147 from FM 2147 to Wirtz Dam

Spur 2147 contains a double yellow stripe with no shoulder striping (see Figure 13). The construction plans show two 10-foot lanes with 1-foot shoulders, as shown in Figure 14.

Figure 13: Spur 2147 Looking North

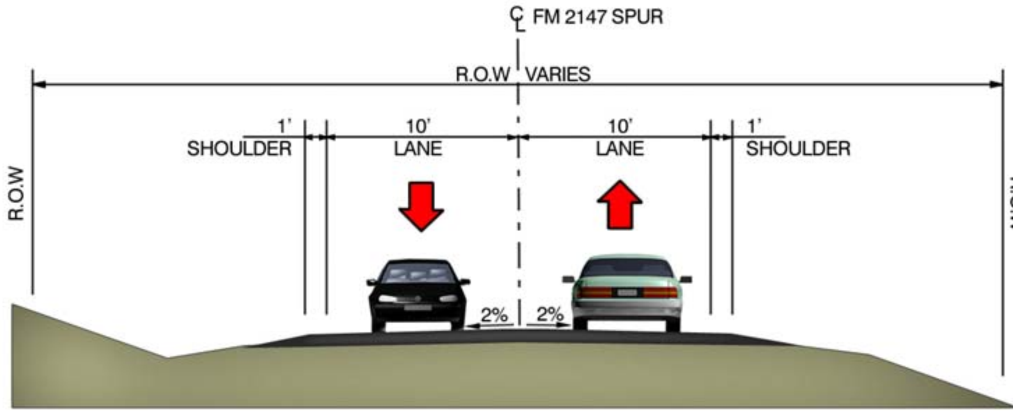

Figure 14: Existing Spur 2147 Typical Section

Extending beyond Spur 2147 is the segment of Wirtz Dam Road that leads to the LCRA property. This road segment is in poor condition and is not striped (see Figure 15).

Figure 15: Wirtz Dam Road Looking South

A typical section of two 12-foot lanes with 10-foot shoulders is recommended along Spur 2147 and Wirtz Dam Road from FM 2147 across the bridge to FM 1431.

An existing low-water crossing connects this road underneath Lake Marble Falls to LCRA property. LCRA built the crossing as a heavy haul road to bring components such as turbines, which are too heavy to cross existing bridges, to the Ferguson Power Plant. As shown in Figure 16, the low water crossing would remain in place and operational alongside the proposed Wirtz Dam Bridge.

Figure 16: Existing and Proposed Crossings at the Wirtz Dam

4.1.3 Wirtz Dam Road: Spur 2147 to FM 1431

As depicted in Figure 17, Wirtz Dam Road extends from Lake Marble Falls to the north, approximately 3.08 miles, to its intersection with FM 1431. A portion of Wirtz Dam Road would need to be realigned to a new location to connect with the proposed bridge. Most of the roadway can be relocated within existing LCRA property, although some right-of-way will need to be acquired from other sources.

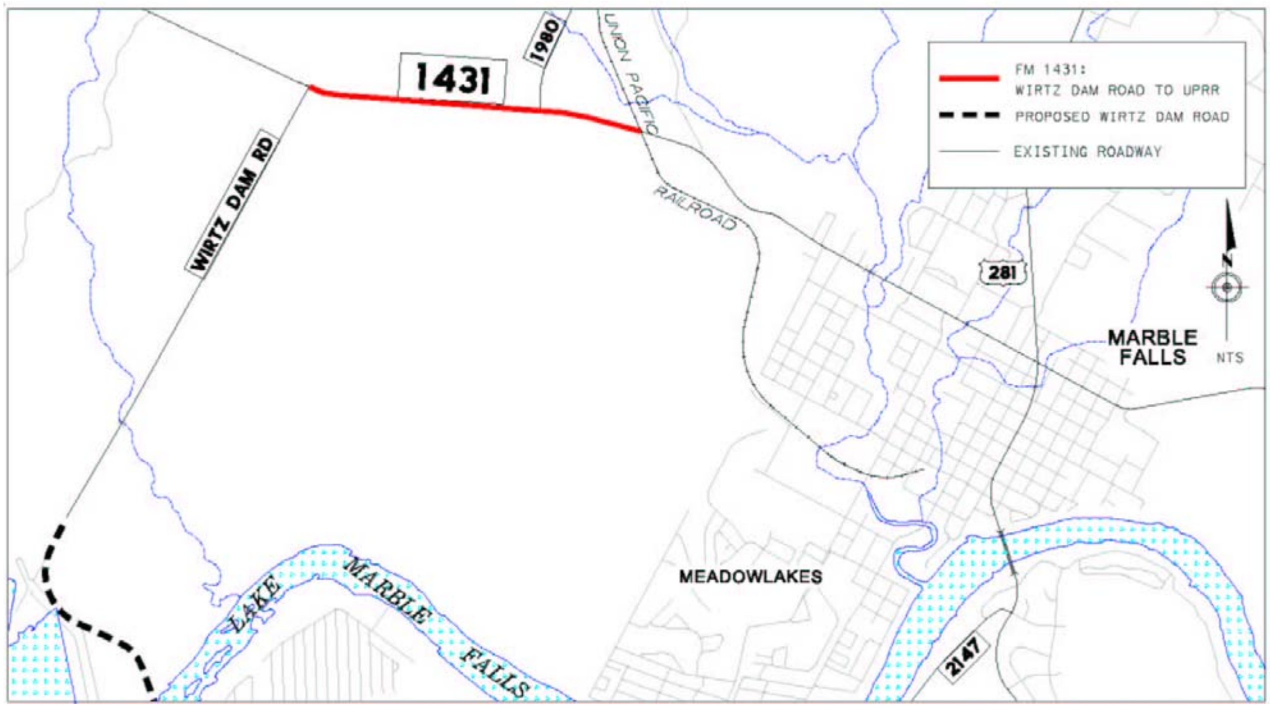

Figure 17: Wirtz Dam Road

The road appears to be a two course surface treatment with a pink tint, suggesting a granite composition. Minimal widening with an overlay and re-striping are required to upgrade this roadway (see Figure 18).

Figure 18: Wirtz Dam Road Looking North Towards FM 1431

The proposed roadway section would consist of one 12-foot lane in each direction with 10-foot shoulders. ROW widths would vary from 150′ (as shown in Figure 19) to 120′ (as shown in Figure 20). The wider ROW section would be needed on either side of the bridge as the road cuts through the granite outcroppings on both sides of the river. A narrower section of 100′ exists from the LCRA property on Wirtz Dam Road north to FM 1431. During the preliminary design phase, a more detailed evaluation should be performed to determine whether an additional 10′ of ROW is needed on each side, to bring the total width up to 120′.

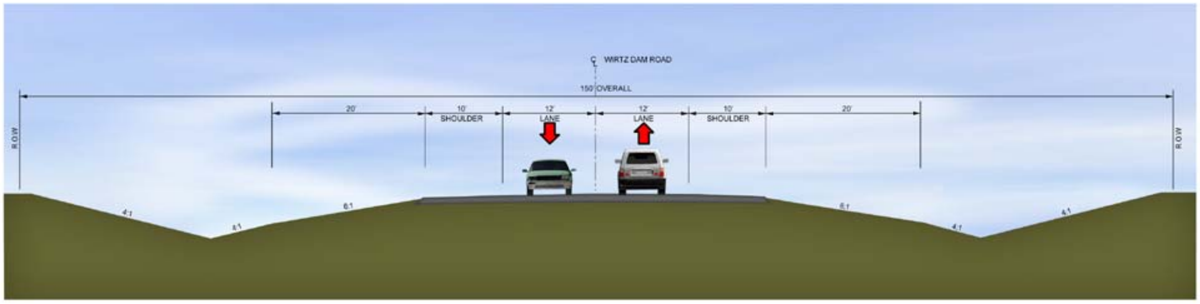

Figure 19: Proposed Wirtz Dam Road with 150′ of ROW

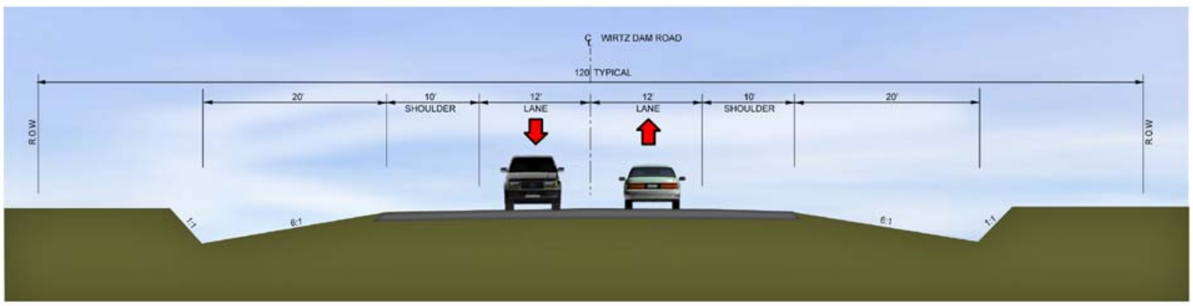

Figure 20: Proposed Wirtz Road with 120′ of ROW

Utility Adjustments: Several Pedernales Electric Company (PEC) power poles will need to be relocated to accommodate the new alignment. Coordination with PEC indicated they can be moved in a timely manner. These power poles are shown in red south of the river on the line diagrammatic schematics in the appendix.

FM 1431: Wirtz Dam Road to the Union Pacific Railroad

The portion of FM 1431 within the study area extends from Wirtz Dam Road to the UPRR. The pavement generally consists of a four-lane (two lanes in each direction), undivided roadway with no shoulders, as shown in Figure 22 and depicted in Figure 23. However, a short section between Wirtz Dam Road and the railroad consists of four 12-foot lanes (two lanes in each direction) with a two-way left turn lane in the center and 10-foot shoulders on each side, as shown in Figure 24.

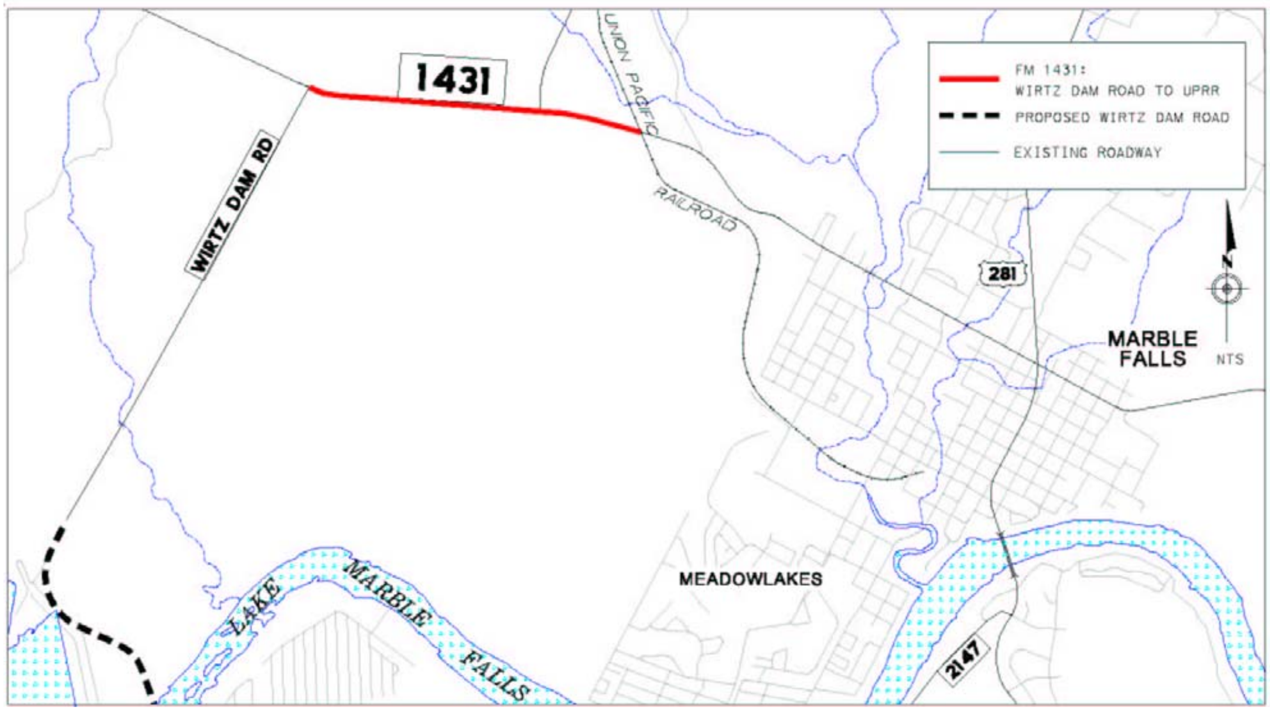

Figure 21: FM 1431

Figure 22: FM 1431 Looking East

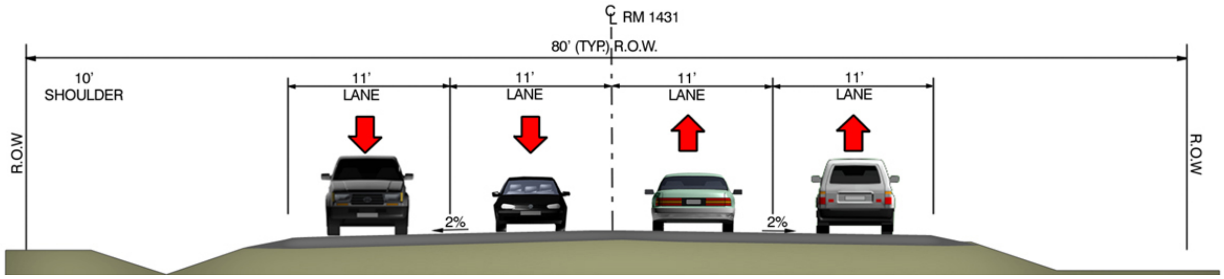

Figure 23: Existing FM 1431 Typical Section

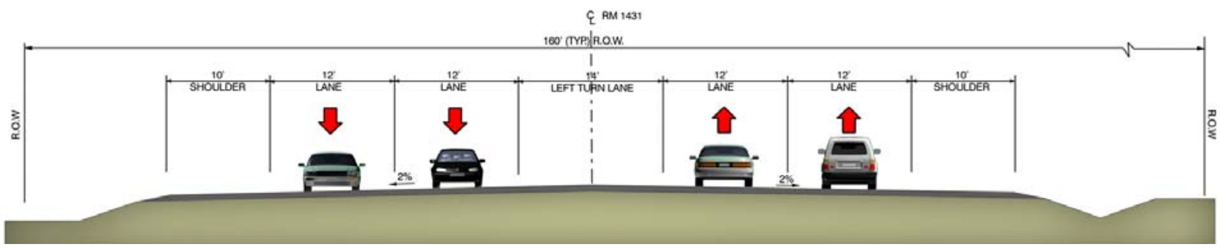

Figure 24: Existing FM 1431

TxDOT is upgrading FM 1431 from the Marble Falls west city limit to the UPRR to a five-lane section: two lanes each direction with TWLTL and shoulders. This same section is proposed along FM 1431 from Wirtz Dam Road to the UPRR.

4.2 Conformity with Design Standards

Existing roadways within the study area were evaluated to determine whether they meet current design criteria. The analysis compared the existing vertical and horizontal curves to the minimum values recommended by the current *TxDOT Roadway Design Manual* for a 45 mph road. Table 2020 shows deficiencies along each roadway segment.

Table 20: Existing Deficiencies Data

Facility	Location	Horizontal Curve	Vertical Curve	Action
FM 2147	US 281 to Spur 2147	- -	X	Rebuild
Spur 2147	FM 2147 to End Spur	X	X	Rebuild
FM 1431	Wirtz Dam Rd to UPRR	X	X	Rebuild

X Indicates a deficiency that warrants action.

Geometric deficiencies were identified along FM 2147 and Spur 2147, as listed in Table21 and shown in Figure 25. A more extensive deficiencies table is in the appendix. While no data was available along the Wirtz Dam Road, field inspection indicated the need for additional pavement widening on all sections of the study area to account for substandard shoulder widths. A concrete traffic barrier or metal beam guard fence would also be needed at objects located within the clear zone, as in the case along Wirtz Dam Road at Deep Creek (shown in Figure 7)[10].

Table 21: Existing Deficiencies

Roadway	Vertical Deficiency	Horizontal Deficiency
Existing RM 1431	V1	-
Existing FM 2147	V2	H1
	V3	-
	V4	-
Existing Spur 2147	V5	H2
	V6	H3

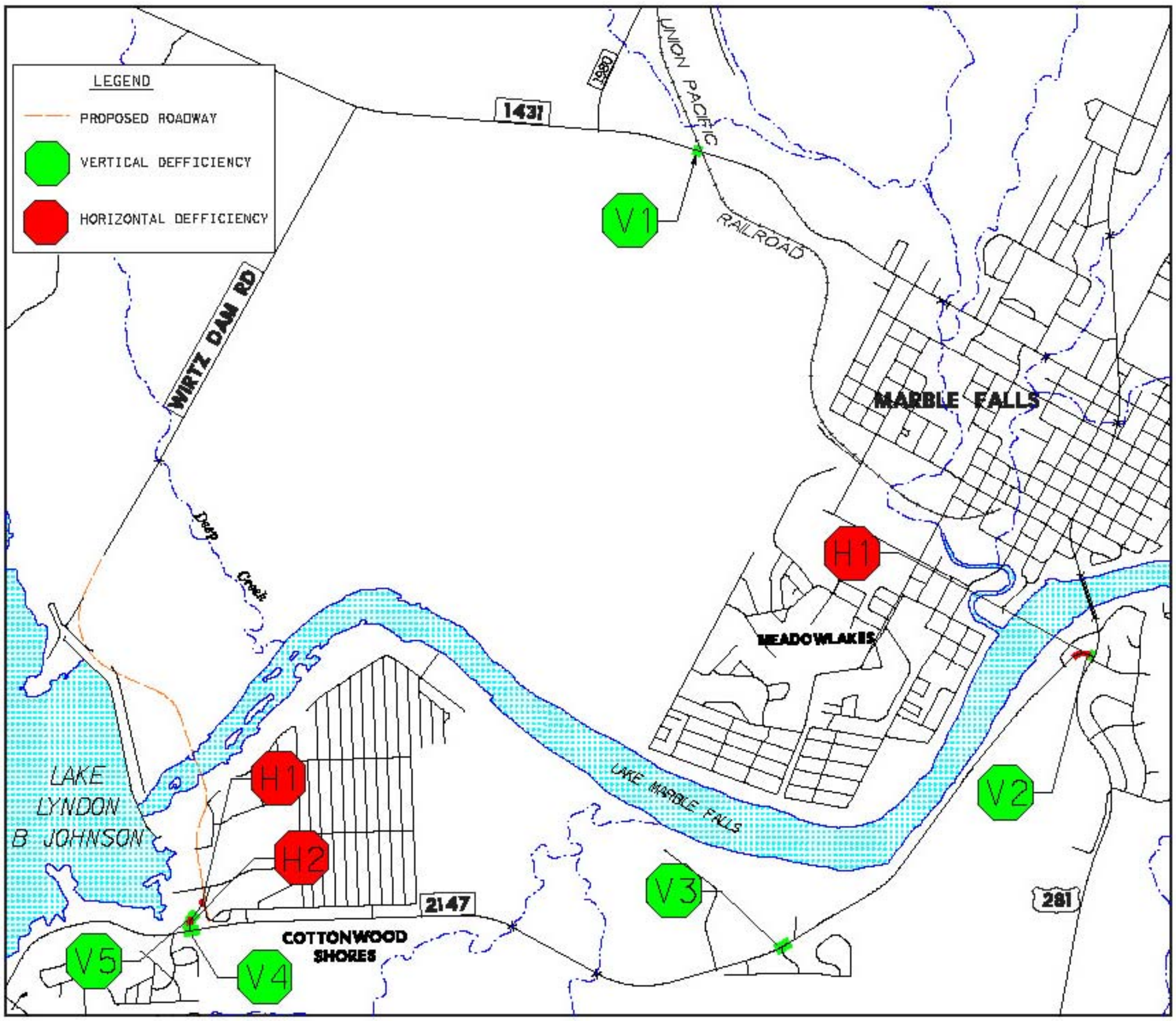

Figure 25: Existing Vertical and Horizontal Curve Deficiencies

Section 5 Funding Requirements

5.1 Right-of-Way Needs

The LCRA owns all of the property downstream of the Wirtz Dam where the proposed Wirtz Dam Road and Bridge would be placed except for some property on the south side of Lake Marble Falls east of the LCRA property. The cost of this property will likely be less expensive than modifying the alignment to keep the proposed facility entirely on LCRA property due to additional rock cutting and utility line relocations that would be required. The right-of-way (ROW) acreage needed is approximately four acres, so assuming a cost of $10,000 per acre a ROW donation would approximate a $40,000 savings to the project cost. The property ownership of each parcel adjacent to the roadways in this study is included in the appendix.

The right-of-way (ROW) acreage required on LCRA property is approximately twenty four acres, which at a conservatively low value of $10,000 per acre, provides a tremendous project cost savings of $240,000 if the property is donated.

5.2 Cost

Estimated construction costs for the bridge and approach roadways are located in the Appendix. Both concrete (Option I) and concrete/steel combination (Option II) bridges are listed for the 10-, 25-, and 100-year storms. An estimate of a concrete slab span bridge is shown as well.

The overall costs are summarized in Table22 below. Approach roadway costs are included with the bridge cost in Table22 for the following limits of Wirtz Dam Road: from the southern limit of Wirtz Dam Road (at Spur 2147) to the bridge (2,000′) and from the bridge to the fence on the LCRA property line at Wirtz Dam Road (4,900′).

Table 22: Overall Wirtz Dam Road and Bridge Costs

Wirtz Dam Road & Bridge Profile	Option I	Option II
Low Water Crossing	$6,415,700	N/A
10-Year	$6,551,100	$8,111,800
25-Year	$7,000,700	$8,408,600
100-Year	$7,503,000	$8,876,700

5.3 Benefit/Cost Ratio

The comparison of the benefits to the cost (B/C ratio) of constructing the Wirtz Dam Road and Bridge project help to determine whether it is beneficial for the community to spend its resources on the project or not. If the value is greater than 1.00, then the project is deemed to be a worthwhile project in that the benefits outweigh the cost of the project.

The benefits of having the Wirtz Dam Road and Bridge constructed can be found in the value of time savings that each vehicle's occupants realize. The Texas Transportation Institute's research in 1998 determined the average driver's wage in 1998 could be estimated at $12.16 for user delay cost determination. Adjusting $12.16 per the Consumer Price Index increases the cost to $14.47 for 2005. Using an average of 1.15 passengers per car raises the per vehicle cost to $16.64. Since approximately four percent of the traffic consists of commercial vehicles, which are valued at $26.03 per hour in user delay cost in 2005 dollars, the final average value of time savings per vehicle is $17.02.

The user delay cost based solely upon road user delay for the non-peak travel time is:

$$\boxed{\left(\frac{\$17.02}{1hour \bullet vehicle}\right)\left(\frac{1hour}{60\min}\right)\left(\frac{7.183\min}{1trip}\right)\left(\frac{2trip}{1day}\right)\left(\frac{7days}{1week}\right)\left(\frac{52weeks}{1year}\right)(354vehicle) = \$525{,}108}$$

The user delay cost based solely upon road user delay for the peak travel time is:

$$\boxed{\left(\frac{\$17.02}{1hour \bullet vehicle}\right)\left(\frac{1hour}{60\min}\right)\left(\frac{8.793\min}{1trip}\right)\left(\frac{2trip}{1day}\right)\left(\frac{7days}{1week}\right)\left(\frac{52weeks}{1year}\right)(3{,}186vehicle) = \$5{,}785{,}255}$$

The total user delay cost is $6,310,363.

The Wirtz Dam Road and Bridge cost for the preferred 100-year bridge Option I (with concrete type IV beams) is estimated at $7,502,989. Therefore, the B/C ratio for the project (from the northern end of Spur 2147 to the north LCRA gate) is 0.84.

Per Table 11, the ADT that would use the bridge will increase; however, the cost of construction will also increase.

Section 6 Conclusions and Recommendations

Currently the traffic patterns work with acceptable levels of service. However, as development continues, the level of service along FM 2147, US 281, and FM 1431 will continue to decrease without an increase in capacity. The right of way of US 281 through Marble Falls cannot be widened due to several adjacent historic buildings. This project provides a way to add capacity to traverse Lake Marble Falls, thus helping to maintain the current LOS on US 281 for many years.

This feasibility study has shown that by looking at the user delay cost alone, the project is almost feasible. Other important intangible benefits that help to make it feasible are:

- Quicker emergency response times for police, fire, and EMS and improved safety through less congestion
- Less wear on vehicles, and cleaner air by reducing vehicle trip times
- Preparing for future development to help control congestion on US 281 and thus improve the quality of life for Marble Falls citizens and for those who visit
- Connectivity is improved if Wirtz Dam Road is extended to the north to connect with FM 1980 and RM 1855 as is shown on the Marble Falls Draft Transportation Master Plan[11]

If the project is deemed to be feasible and construction funding is secured, several schedule recommendations follow for a total project development time of 3.5 years:

- Enter into the preliminary design phase to develop a detailed geometric schematic, an environmental assessment, hold public meetings, and develop right of way documents (9 months)
- Acquire the needed right of way (12 months)
- While the right of way is being acquired, develop the construction plans for the roadway and bridge from FM 2147 to the LCRA north gate intersection including the bridge and have them reviewed (9 months)
- Adjust the utilities (5 months)
- Review the plans, specifications, and estimate and let the project to construction (4 months)
- Construct the project (15 months)

Funding for the project was submitted in the Federal reauthorization Transportation Bill (SAFETEA-LU), but was not approved. Once funding is secured for this project, it is recommended that the improvements on Wirtz Dam Road extend from the north gate of LCRA's property, north to FM 1431 with minimal widening, an overlay, and re-striping.

An advance funding agreement between the beneficiaries of the project is one way to spread the cost of the project around. Although the B/C ratio is currently below 1.0, traffic volumes throughout the area will only increase over time as Table 9, on page 11 suggests, thereby increasing the B/C value. Unfortunately, it is probable that construction costs will also increase during this same time period causing a negative effect on the B/C value.

Appendix

A. **Line Diagrammatic Schematics and Profiles**

B. **Traffic Counts**

C. **Highway Capacity Analysis**

D. **HEC-RAS Run**

E. **Cost Estimate**

F. **Roadway Deficiencies Table**

G. **Property Owners**

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